Applications of Self-Powered Modulating Retroreflectors

Kue Chun, Noulie Theofylaktos

Abstract

NASA Glenn Research Center, in partnership with the U.S. Naval Research Laboratory, has developed self-powered modulating retroreflectors (SMRR) for energy efficient, wireless communications applications. A modulating retroreflector (MRR) consists of a multiple quantum well (MQW) optical detector mounted in front of a retroreflector. The SMRR is integrated the MRR with monolithically integrated module (MIM) photovoltaic (PV) receivers to generate power from interrogating laser-light. SMRRs will provide self power capability that would eliminate batteries or other power sources for MRR drive electronics and sensors. The device can be applied to optical communications, wireless sensor and optical ID tags without a battery. Potential applications and preliminary tests based on a lunar surface communications and navigation simulation will be presented.

Applications of Self Powered Modulating retroreflectors

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- NASA Glenn Research Center, in partnership with the U.S. Naval Research Laboratory, has developed self-powered modulating retroreflectors (SMRR) for energy efficient, wireless communications applications. A modulating retroreflector (MRR) consists of a multiple quantum well (MQW) optical detector mounted in front of a retroreflector and a SMRR is integrated the MRR with monolithically integrated module (MIM) photovoltaic (PV) receivers to generate power from interrogating laser-light. SMRRs will provide self power capability that would eliminate batteries or other power sources for MRR drive electronics and sensors. The device can be applied to optical communications, wireless sensor and optical ID tags without a battery.

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Objective:

Develop and demonstrate optical data link system based on the following technologies;

- The system exploits the shift in the absorption peak of the multi-quantum well (MQW) under an applied reverse bias (Figure 1) so that an interrogation laser beam is either passed or blocked by the MQW. The device then modulates the reflected light (Modulating Retroreflectpr, MRR) enabling binary encoding of the data to be transferred (Figure 2).
- Absorption of light changes when voltage is applied
  - contrast ratio is between 2:1 and 3:1

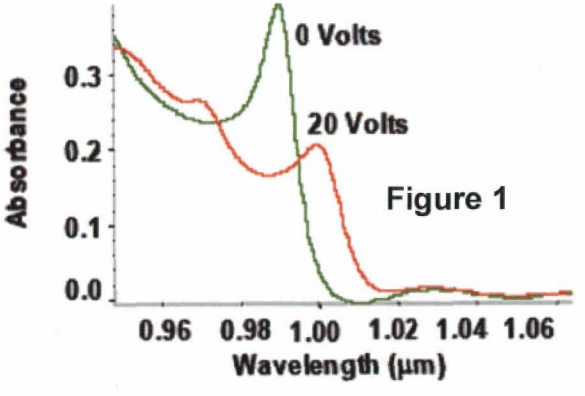
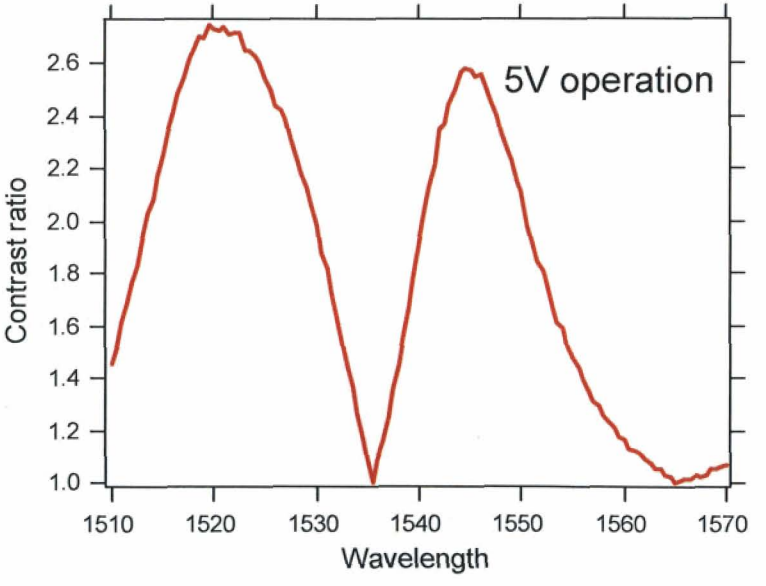
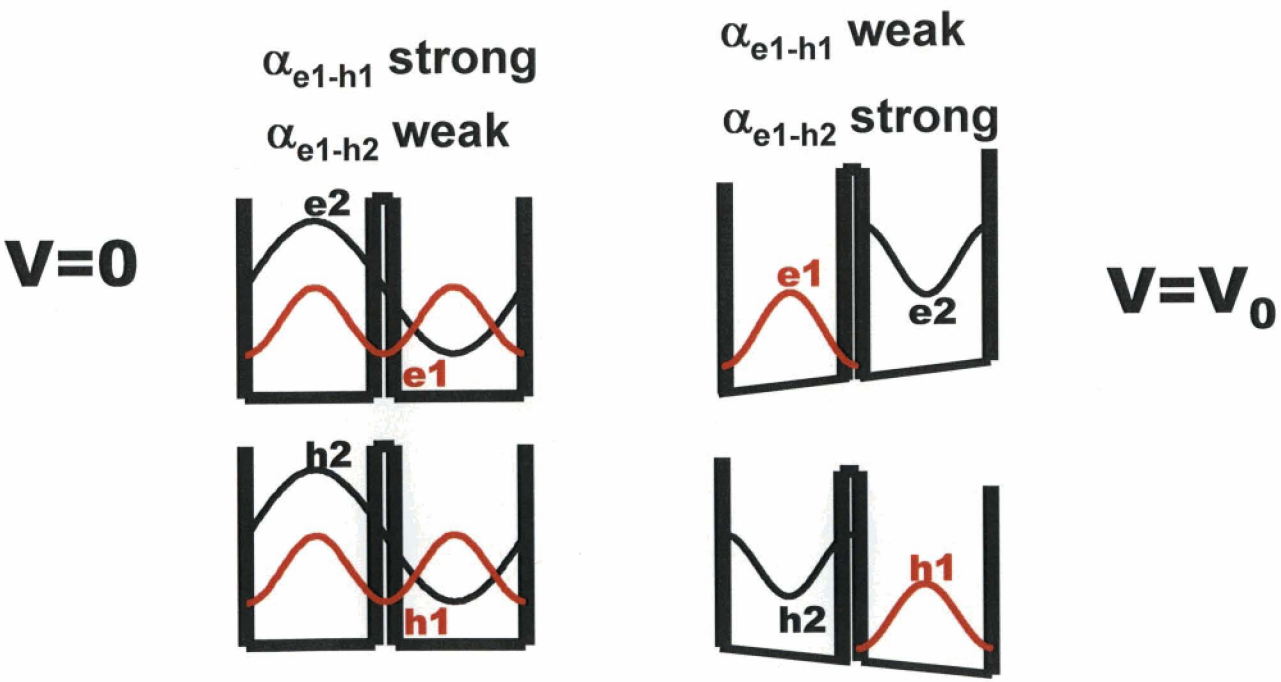


Figure 1



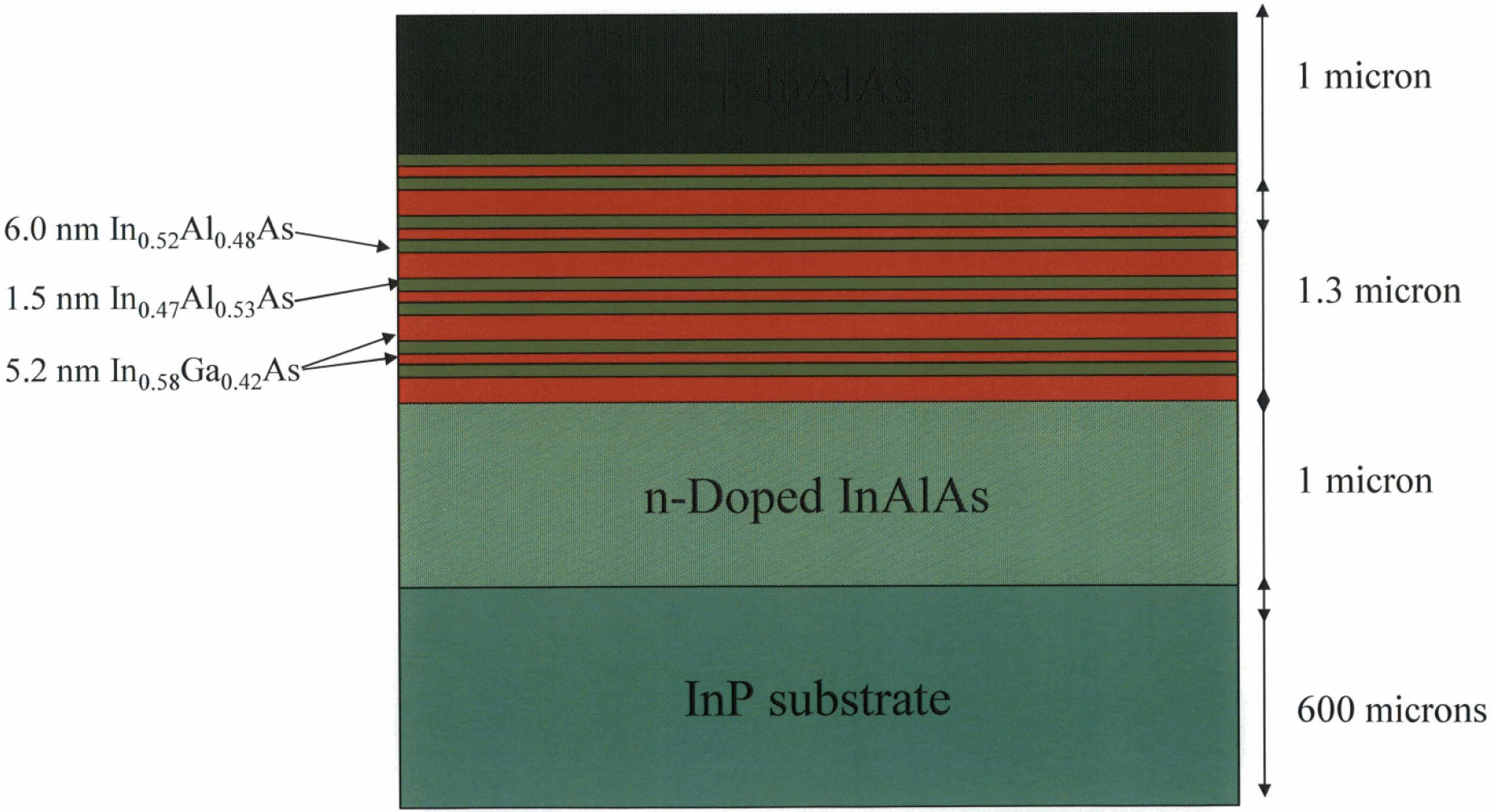
Coupled MQW Design

- Work by changing their absorption under electric field
- A thin barrier splits the ground electron and hole state into a symmetric and antisymmetric state
- A very small field breaks the symmetry and dramatically changes the wave functions
  - Change in wavefunction changes the absorption strength
- Coupled well modulators require low voltages ~ 3-7 V



Coupled MQW Design

The MQW layer structure is a strain-balanced InGaAs/InAlAs coupled well designed to operate in the eye safe 1550 nm wavelength region



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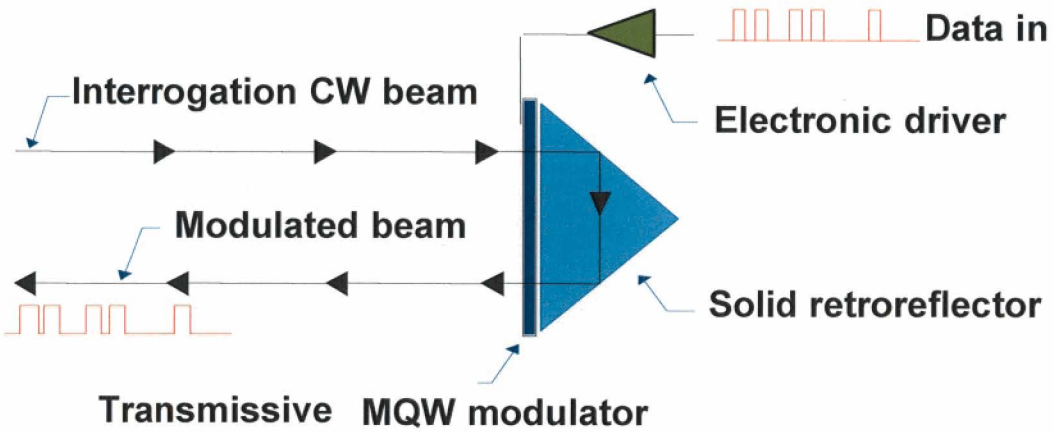

Figure 2. Modulating Retro Reflector (MRR)

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Monolithically integrated module (MIM) consisting of many individual solar cells monolithically integrated on single wafer. Used for photovoltaic energy generation. Integrated MIM PV receiver with MQW MRR shown in Figure 3.

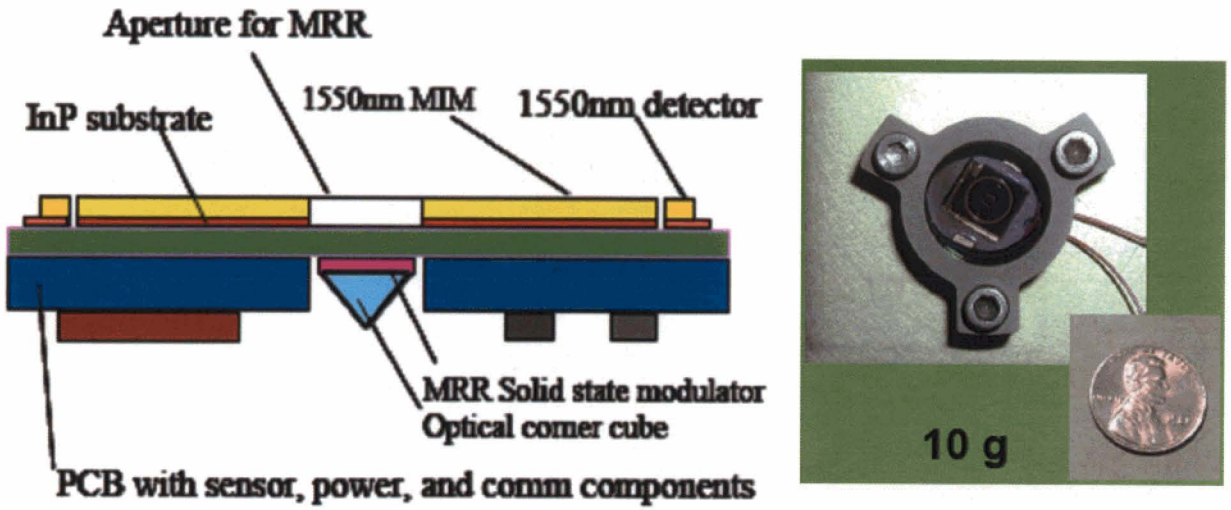
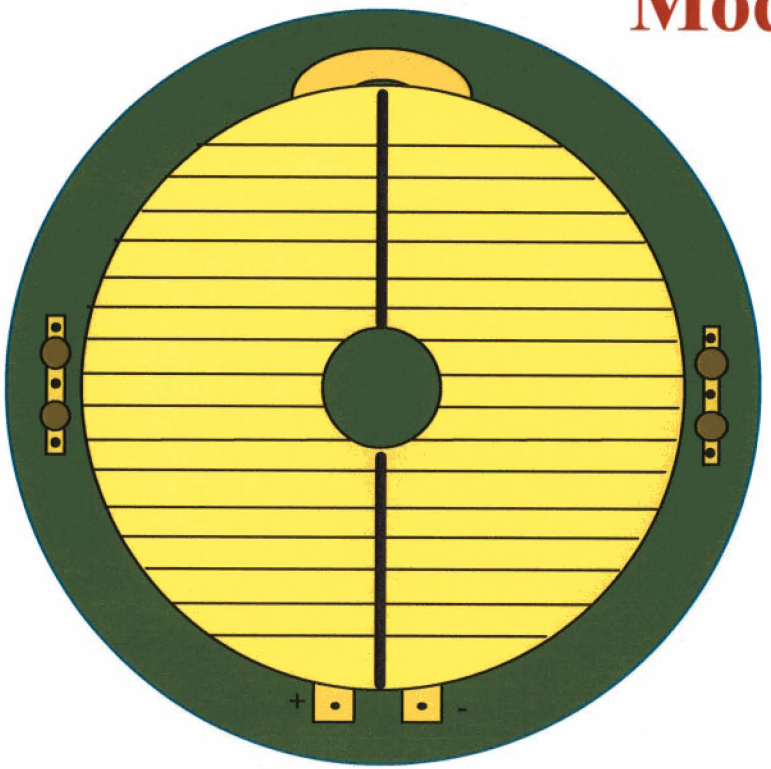


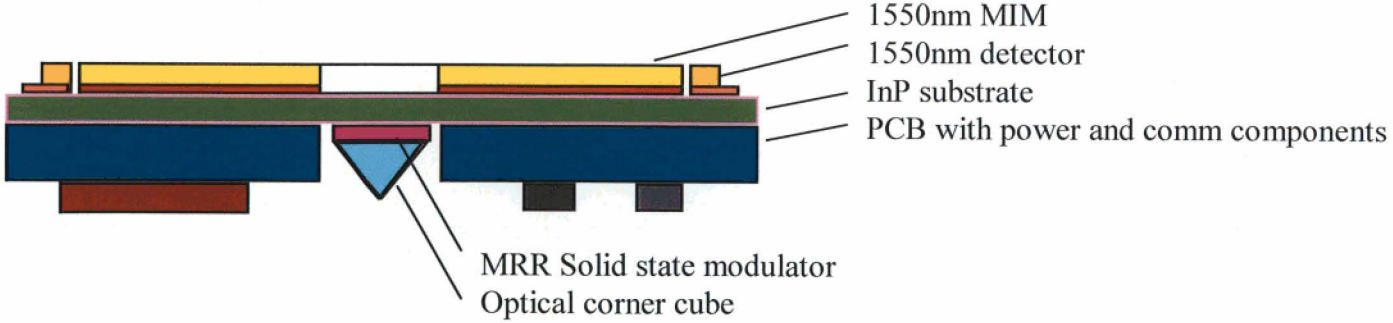
Figure 3

1550nm Integrated Power/Comm Module Concept



Plan view

Cross sectional view



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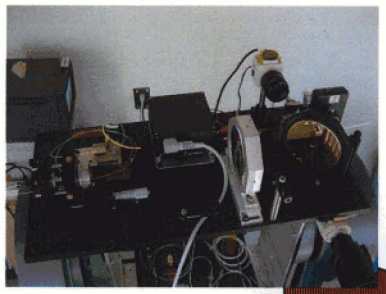
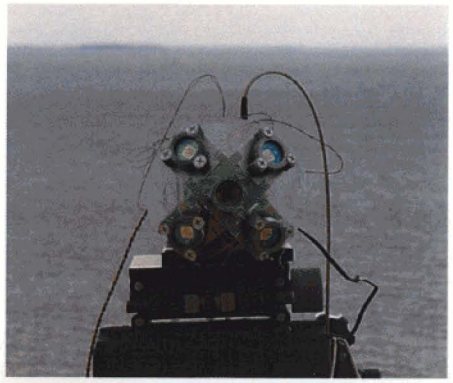
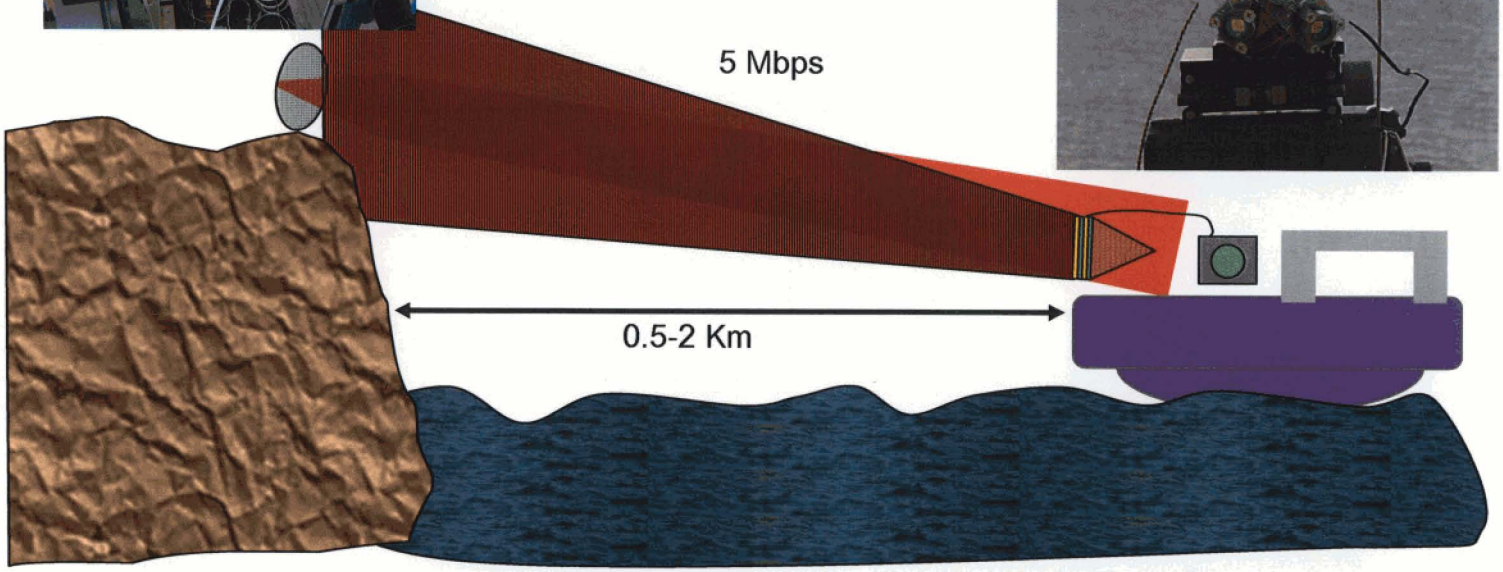
Field Trial Test at Chesapeake Beach (2004)



Real-Time color, compressed Video Streaming at 1550 nm; 30 fps; 5 Mbps;~100 mW to drive MRR





SPIE 1560-60, Mahon, et.al., "1550-nm 1-km maritime link at Chesapeake Beach".

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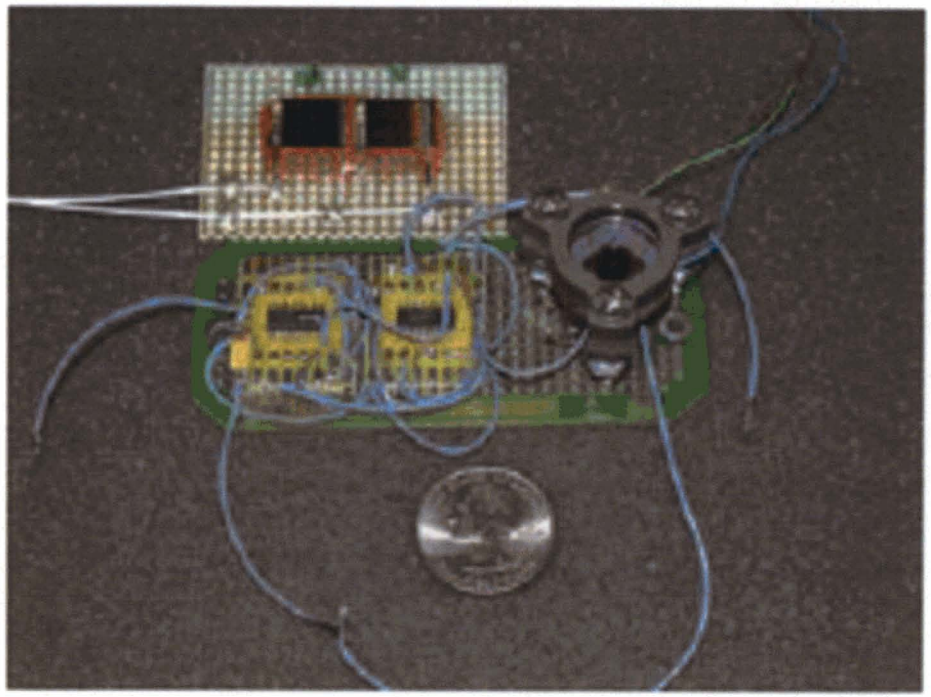
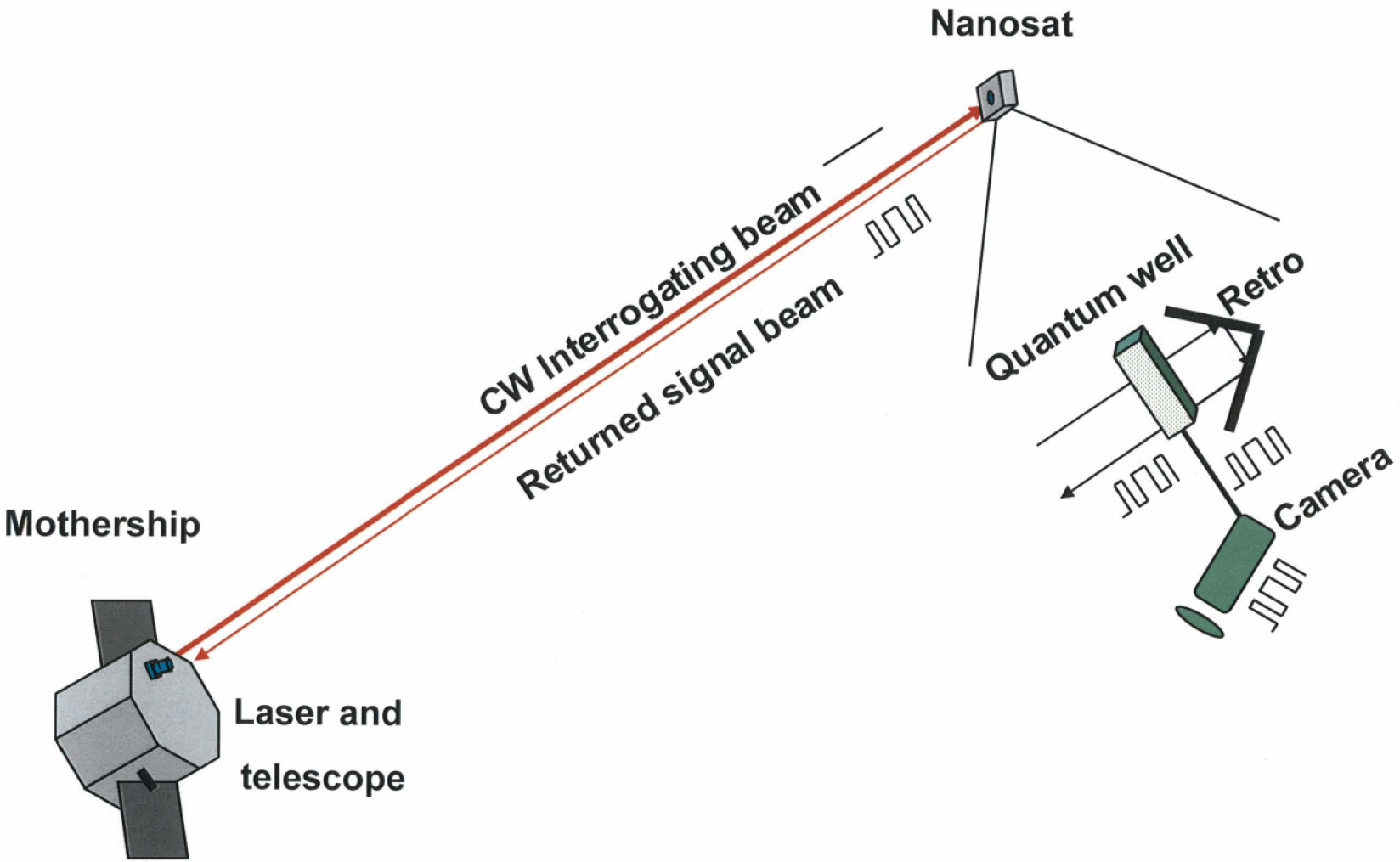


PV powered MRR ID-Tag bread board system

Inter-Spacecraft Optical Communications



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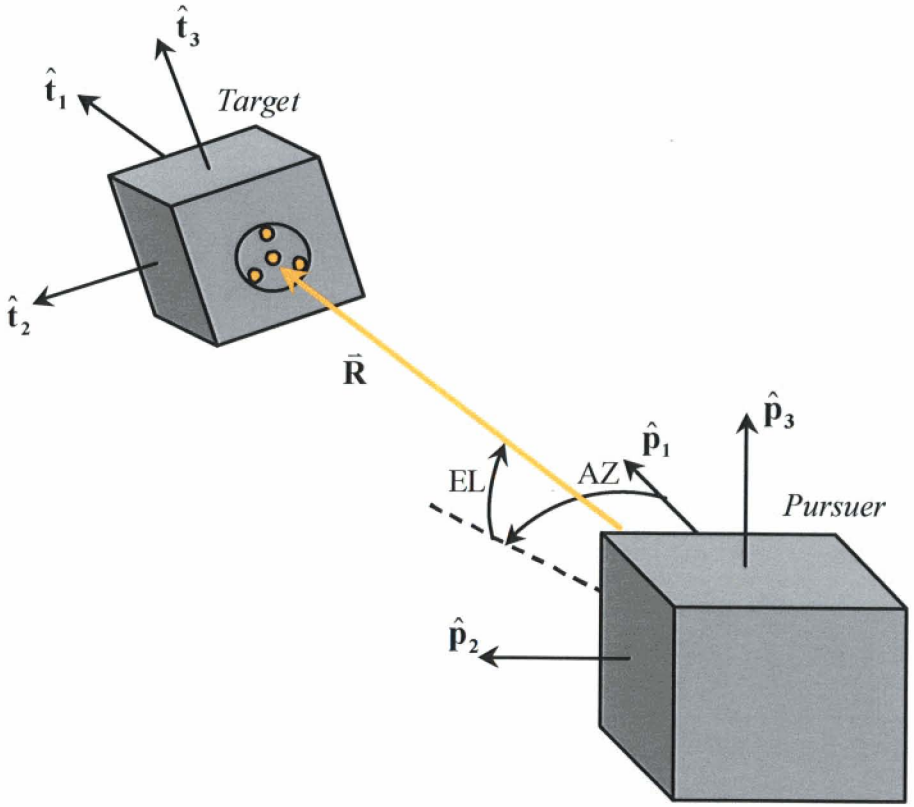

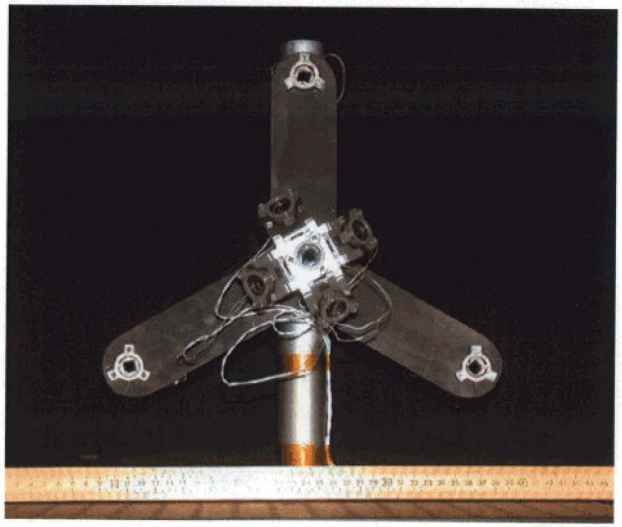

Inter spacecraft Relative Navigation